421919

FLOOD INSURANCE STUDY

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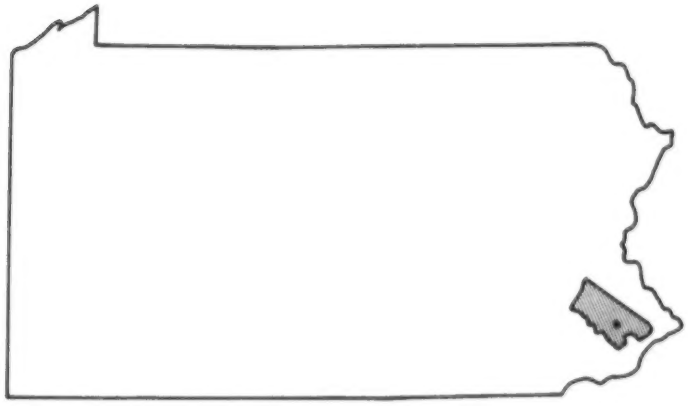
TOWNSHIP OF WORCESTER, PENNSYLVANIA
MONTGOMERY COUNTY



SEPTEMBER 16, 1980

federal emergency management agency
federal insurance administration

COMMUNITY NUMBER - 421919

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PUBLISHED SEPARATELY:

Flood Insurance Rate Map

FLOOD INSURANCE STUDY
TOWNSHIP OF WORCESTER, PENNSYLVANIA

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study investigates the existence and severity of flood hazards in the Township of Worcester, Montgomery County, Pennsylvania, and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study will be used to convert Worcester to the regular program of flood insurance by the Federal Insurance Administration (FIA). Local and regional planners will use this study in their efforts to promote sound flood plain management.

In some states or communities, flood plain management criteria or regulations may exist that are more restrictive or comprehensive than those on which these federally-supported studies are based. These criteria take precedence over the minimum federal criteria for purposes of regulating development in the flood plain, as set forth in the Code of Federal Regulations at 24 CFR, 1910.1(d). In such cases, however, it shall be understood that the state (or other jurisdictional agency) shall be able to explain these requirements and criteria.

1.2 Authority and Acknowledgements

The source of authority for this Flood Insurance Study is the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The hydrologic and hydraulic analyses for this study were performed by the Philadelphia District of the U. S. Army Corps of Engineers for the Federal Insurance Administration, under Inter-Agency Agreement No. IAA-H-10-77, Project Order No. 9, and Amendment No. 2. This work was completed in March 1979.

1.3 Coordination

A search for basic data was made at all levels of government. On August 30, 1976, an initial Consultation and Coordination Officer's (CCO) meeting was held attended by representatives of the FIA, the Township of Worcester, and the U. S. Army Corps of Engineers (COE).

The methods of study were accepted and the sources of basic data identified at the CCO meeting. During the course of the study, a community map and a comprehensive plan were supplied by township officials. On January 11, 1980, a final CCO meeting was held with representatives of the FIA, the township, and the COE to discuss the results of the study.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the incorporated area of the Township of Worcester, Montgomery County, Pennsylvania. The area of study is shown on the Vicinity Map (Figure 1).

Zacharias Creek and North Branch Zacharias Creek were studied by detailed methods. The areas studied by detailed methods were selected with priority given to all known flood hazard areas and areas of projected development and proposed construction for the next five years, through March 1984.

Skippack Creek and Tributaries A and B to Skippack Creek were studied by approximate methods. Approximate methods of analysis were used to study those areas having low development potential and minimal flood hazards as identified at the initiation of the study. The scope and methods of study were proposed to and agreed upon by the FIA.

2.2 Community Description

The Township of Worcester is located in the central portion of Montgomery County in southeastern Pennsylvania. Worcester is bordered by the Townships of Towamencin and Upper Gwynedd to the north, the Township of Whitpain to the east, the Townships of East and West Norriton to the southwest, the Township of Lower Providence to the south, and the Township of Skippack to the west.

The area now known as the Township of Worcester was originally known as the Township of New Bristol. The present township boundaries were formed in 1734 when 25 landholders joined together to petition the court for the formation of Worcester. The earliest settlers in the township were of English, Welsh, German and Dutch origin. According to the 1970 census, the township is a community of approximately 4,200 and covers an area of 16.0 square miles. Worcester's growth

FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWNSHIP OF WORCESTER, PA
(MONTGOMERY CO.)

APPROXIMATE SCALE

6,000 0 6,000 12,000 18,000 FEET

VICINITY MAP

rate is relatively moderate compared to the extensive suburbanization which Montgomery County experienced during the period from 1940 to 1960.

Worcester is rural in nature with about half of the total land area devoted to agricultural use. Residential development is located in and around the areas of the Village of Fairview, Center Point, Bethel Hill and Cedars. Commercial and industrial development is very limited. The land adjacent to Zacharias Creek and North Branch Zacharias Creek is characterized by gently rolling hills. This land is used mostly for agricultural purposes with some areas of very sparse development.

The climate of the area is characterized by warm summers, when temperatures may rise above 85 degrees Fahrenheit (°F), and cool winters, when temperatures may fall below 20°F. The annual precipitation in the area averages 42 inches with a major portion occurring in the late spring and summer (Reference 1).

2.3 Principal Flood Problems

Worcester is subject to flooding from Zacharias and North Branch Zacharias Creeks. Flooding on the creeks usually results from heavy rainfall associated with thunderstorms. The area is also susceptible to hurricanes, flash floods, and flooding from snowmelt. Since 1960, the U. S. Geological Survey (USGS) has maintained a stream gage on Zacharias Creek downstream of Green Hill Road. The flood of record occurred on September 13, 1971, and had a discharge of 10,000 cubic feet per second and a flood height of 181.85 (Reference 2). Major floods in the township also occurred in 1970, 1972, and 1973. The corresponding recurrence intervals for the 1971 and 1972 floods were 100 years and 25 years, respectively; the recurrence intervals for the 1970 and 1973 floods were under 10 years.

2.4 Flood Protection Measures

No flood control measures are currently existing or proposed that would alter the flood flows on streams within the study area. The National Weather Service issues flood warnings and anticipated weather conditions to local and county officials and the news media who, in turn, inform the area residents.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood

hazard data for this study. Flood events of a magnitude which are expected to be equalled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for flood plain management and for flood insurance premium rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10-, 2-, 1-, and 0.2-percent chance, respectively, of being equalled or exceeded during any year. Although the recurrence interval represents the long-term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than one year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (one-percent chance of annual occurrence) in any 50-year period is about 40 percent (four in ten) and, for any 90-year period, the risk increases to about 60 percent (six in ten). The analyses reported here reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for floods of the selected recurrence intervals for each flooding source studied in detail affecting the community.

The hydrology for Zacharias Creek was developed by the Philadelphia District of the COE in a Special Flood Hazard Report and used in this report to insure the consistency of technical data (Reference 3). Since 1960, a stream gaging station has been maintained by the USGS on Zacharias Creek just downstream of Green Hill Road (Reference 2). Since the record of this gage was only 14 years in length at the time of the original analyses, additional data was obtained from gaging stations in the vicinity of the Zacharias Creek watershed. Discharge-frequency relationships for Zacharias Creek and North Branch Zacharias Creek were developed from available gage data through the use of a regional frequency analysis and distributed throughout the basin by proportional drainage area relationships (Reference 4). Peak flows for the 500-year flood were obtained by extrapolating the discharge frequency curve computed for flood events up to the 100-year flood.

A summary of drainage area-peak discharge relationships for the streams studied by detailed methods is shown in Table 1, "Summary of Discharges."

TABLE 1 - SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
ZACHARIAS CREEK					
USGS Crest Stage Partial Record Gage	7.3	4,200	7,500	9,600	15,000
Downstream of North Branch Zacharias Creek	2.7	2,100	3,700	4,700	7,400
NORTH BRANCH ZACHARIAS CREEK					
Confluence with Zacharias Creek	0.7	500	900	1,200	1,900

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of the flooding sources studied in detail were carried out to provide estimates of the elevations of floods of the selected recurrence intervals along each of these flooding sources.

Water-surface elevations of floods of the selected recurrence intervals were computed through the use of the COE HEC-2 step-backwater computer program (References 5 and 6). Cross sections for the backwater analyses of Zacharias Creek and North Branch Zacharias Creek were field-surveyed and located at close intervals above and below bridges and culverts in order to compute the significant backwater effects of these structures.

Channel roughness factors (Manning's "n") for the hydraulic computations were assigned on the basis of field inspection of flood plain areas and engineering judgment. The roughness value for the channel of all streams studied in detail was 0.035. The roughness values for the overbanks of all the streams studied in detail ranged from 0.050 to 0.100.

Starting water-surface elevations for Zacharias Creek were developed by the Philadelphia District of the COE from coincident conditions of flood events on Skippack Creek and Zacharias Creek. Starting water-surface elevations for North Branch Zacharias Creek were obtained from the backwater computations of Zacharias Creek.

Flood profiles were drawn showing computed water-surface elevations to an accuracy of 0.5 foot for floods of the selected recurrence intervals. Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway is computed (Section 4.2), selected cross-section locations are also shown on the Flood Boundary and Floodway Map (Exhibit 2).

The 100-year flood for the streams studied by approximate methods was approximated by field inspection of the area, the examination of available topographic mapping, engineering judgment, and the use of the FIA Flood Hazard Boundary Map for the Township of Worcester (References 7 and 8).

All elevations used in this study are referenced to the National Geodetic Vertical Datum of 1929 (NGVD), formerly referred to as Sea Level Datum of 1929. Locations of the elevation reference marks used in the study are shown on the maps.

The hydraulic analyses for this study are based on the effects of unobstructed flow. The flood elevations shown on the profiles are valid only if hydraulic structures remain unobstructed and do not fail.

4.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

The National Flood Insurance Program encourages state and local governments to adopt sound flood plain management programs. Therefore, each Flood Insurance Study includes a flood boundary map designed to assist communities in developing sound flood plain management measures.

4.1 Flood Boundaries

In order to provide a national standard without regional discrimination, the 100-year flood has been adopted by the FIA as the base flood for purposes of flood plain management measures. The 500-year flood is employed to indicate additional areas of flood risk in the community. For each stream studied in detail, the boundaries of the 100- and 500-year floods have been delineated using the flood elevations determined at each cross section; between cross sections, the boundaries were interpolated using topographic maps enlarged to a scale of 1:12,000 with a contour interval of 10 feet (Reference 7). In cases where the 100- and 500-year flood boundaries are close together, only the 100-year boundary has been shown.

For streams studied by approximate methods, the boundary of the 100-year flood was approximated by the field inspection of the area, the examination of available topographic mapping, engineering judgment, and the use of FIA's published Flood Hazard Boundary Maps (References 7 and 8).

The boundaries of the 100- and 500-year floods are shown on the Flood Boundary and Floodway Map (Exhibit 2). Small areas within the flood boundaries may lie above the flood elevations and, therefore, may not be subject to flooding. Owing to limitations of the map scale and lack of detailed topographic data, such areas are not shown.

4.2 Floodways

Encroachment on flood plains, such as artificial fill, reduces the flood-carrying capacity, increases the flood heights of streams, and increases flood hazards in areas beyond the encroachment itself. One aspect of flood plain management involves balancing the economic gain from flood plain development against the resulting increase in flood hazard. For purposes of the Flood Insurance Program, the concept of a floodway is used as a tool to assist local communities in this aspect of flood plain management. Under this concept, the area of the 100-year flood is divided into a floodway and a floodway fringe. The floodway is the channel of a stream plus any adjacent flood plain areas that must be kept free of encroachment in order that the 100-year flood can be carried without substantial increases in flood heights. Minimum standards of the FIA limit such increases in flood heights to 1.0 foot, provided that hazardous velocities are not produced. The floodways in this report are presented to local agencies as minimum standards that can be adopted or that can be used as a basis for additional studies.

The floodways presented in this study were computed on the basis of equal conveyance reduction from each side of the flood plains. The results of these computations are tabulated at selected cross sections for each stream segment for which a floodway is computed (Table 2).

As shown on the Flood Boundary and Floodway Map (Exhibit 2), the floodway widths were determined at cross sections; between cross sections, the boundaries were interpolated. In cases where the boundaries of the floodway and the 100-year flood are either close together or collinear, only the floodway boundary has been shown.

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FT.)	SECTION AREA (SQ. FT.)	MEAN VELOCITY (F.P.S.)	REGULATORY (NGVD)	WITHOUT FLOODWAY (NGVD)	WITH FLOODWAY (NGVD)	INCREASE (FEET)
Zacharias Creek								
A	2,050[1]	270	1,400	7.0	173.3	173.3	173.3	0.0
B	5,920[1]	380	1,140	7.4	191.3	191.3	191.3	0.0
C	9,300[1]	340	1,230	4.8	212.0	212.0	212.0	0.0
D	10,190[1]	590	3,730	1.6	223.9	223.9	223.9	0.0
E	11,375[1]	310	1,140	5.2	228.2	228.2	228.2	0.0
F	12,720[1]	270	1,320	4.0	237.8	237.8	237.8	0.0
G	13.750[1]	240	920	5.8	246.5	246.5	246.5	0.0
H	15,180[1]	290	890	5.3	255.9	255.9	255.9	0.0
I	16,850[1]	280	850	2.4	269.2	269.2	269.2	0.0
J	18,625[1]	230	490	4.1	281.7	281.7	281.7	0.0
K	20,850[1]	220	320	4.0	296.4	296.4	296.4	0.0
L	21,550[1]	210	370	3.5	302.0	302.0	302.0	0.0
North Branch Zacharias Creek								
A	2,175[2]	180	280	3.1	278.1	278.1	278.1	0.0
B	3,075[2]	130	220	3.8	291.7	291.7	291.7	0.0
C	4,325[2]	140	170	2.9	310.1	310.1	310.1	0.0

[1] Feet above corporate limits

[2] Feet above confluence with Zacharias Creek

TABLE 2

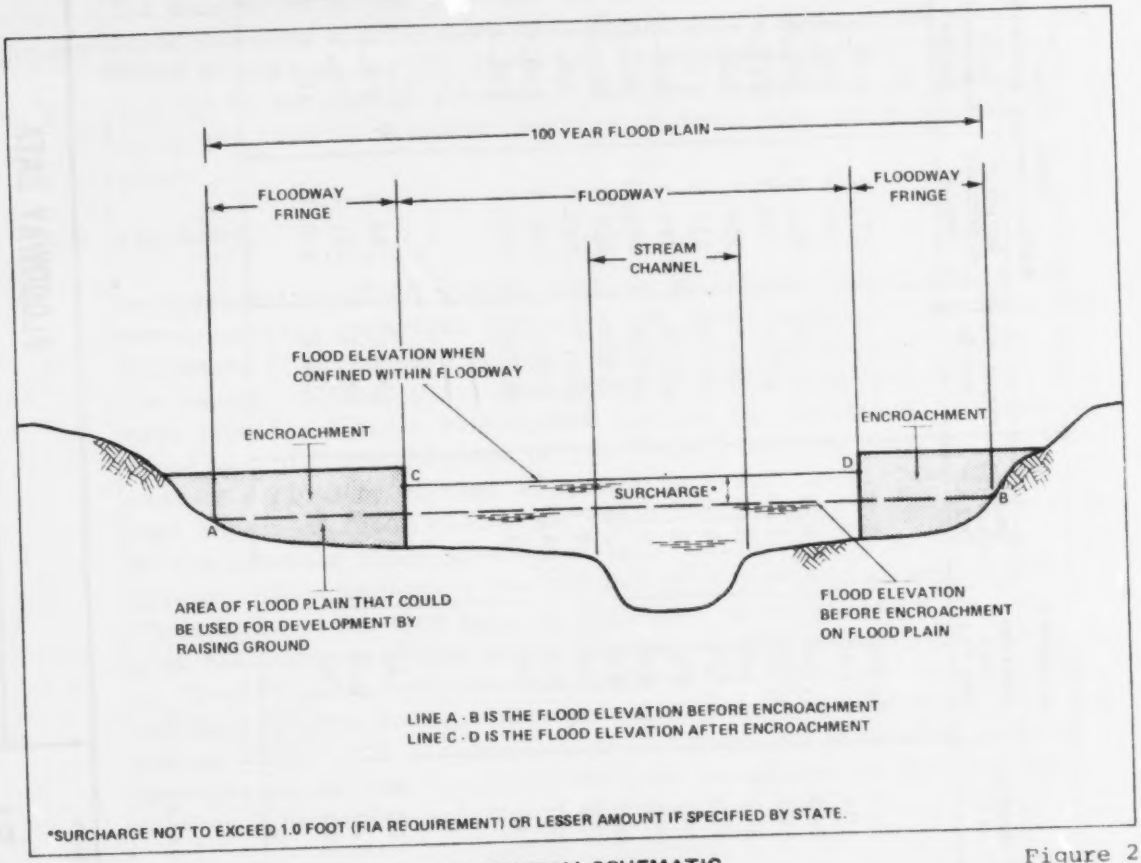
FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWNSHIP OF WORCESTER, PA
(MONTGOMERY CO.)

FLOODWAY DATA

ZACHARIAS CREEK AND NORTH BRANCH ZACHARIAS CREEK

The area between the floodway and the boundary of the 100-year flood is termed the floodway fringe. The floodway fringe thus encompasses the portion of the flood plain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood by more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to flood plain development are shown in Figure 2.


100 YEAR FLOOD PLAIN
FLOODWAY FRINGE
FLOODWAY
FLOODWAY FRINGE
STREAM CHANNEL
FLOOD ELEVATION WHEN CONFINED WITHIN FLOODWAY
ENCROACHMENT
ENCROACHMENT
C
D
A
B
SURCHARGE*
AREA OF FLOOD PLAIN THAT COULD BE USED FOR DEVELOPMENT BY RAISING GROUND
FLOOD ELEVATION BEFORE ENCROACHMENT ON FLOOD PLAIN
LINE A - B IS THE FLOOD ELEVATION BEFORE ENCROACHMENT
LINE C - D IS THE FLOOD ELEVATION AFTER ENCROACHMENT
*SURCHARGE NOT TO EXCEED 1.0 FOOT (FIA REQUIREMENT) OR LESSER AMOUNT IF SPECIFIED BY STATE.

FLOODWAY SCHEMATIC

Figure 2

Floodwaters from Zacharias Creek and North Branch Zacharias Creek were found to have hazardous velocities. Encroachment into areas subject to inundation by floodwaters having hazardous velocities aggravates the risk of flood damage, and heightens potential flood hazards by further increasing velocities. To provide guidance for encroachment into these areas, a proposed floodway is delineated for that part of the 100-year flood plain that conveys flow.

5.0 INSURANCE APPLICATION

In order to establish actuarial insurance rates, the FIA has developed a process to transform the data from the engineering study into flood insurance criteria. This process includes the determination of reaches, Flood Hazard Factors (FHFs), and flood insurance zone designations for each flooding source affecting the Township of Worcester.

5.1 Reach Determinations

Reaches are defined as lengths of watercourses having relatively the same flood hazard, based on the average weighted difference in water-surface elevations between the 10- and 100-year floods. This difference does not have a variation greater than that indicated in the following table for more than 20 percent of the reach.

Average Difference Between 10- and 100-Year Floods	Variation
Less than 2 feet	0.5 foot
2 to 7 feet	1.0 foot
7.1 to 12 feet	2.0 feet
More than 12 feet	3.0 feet

The locations of the reaches determined for the flooding sources of the Township of Worcester are shown on the Flood Profiles (Exhibit 1) and are summarized in the Flood Insurance Zone Data Table (Table 3).

5.2 Flood Hazard Factors

The FHF is the FIA device used to correlate flood information with insurance rate tables. Correlations between property damage from floods and their FHFs are used to set actuarial insurance premium rate tables based on FHFs from 005 to 200.

The FHF for a reach is the average weighted difference between the 10- and 100-year flood water-surface elevations expressed to the nearest 0.5 foot, and shown as a three-digit code. For example, if the difference between water-surface elevations of the 10- and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year water-surface elevations is greater than 10.0 feet, accuracy for the FHF is to the nearest foot.

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1.0% (100-YEAR) FLOOD AND			FHF	ZONE	BASE FLOOD ELEVATION[3] (NGVD)
		10% (10 YR.)	2% (50 YR.)	0.2% (500 YR.)			
Zacharias Creek Reach 1	05	-2.3	-0.8	+1.6	025	A5	Varies
North Branch Zacharias Creek Reach 1	05	-1.3	-0.4	+0.9	015	A3	Varies

[1]Flood Insurance Rate Map Panel
[2]Weighted average
[3]Rounded to the nearest foot - see map

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWNSHIP OF WORCESTER, PA
(MONTGOMERY CO.)

FLOOD INSURANCE ZONE DATA

ZACHARIAS CREEK AND NORTH BRANCH ZACHARIAS CREEK

5.3 Flood Insurance Zones

After the determination of reaches and their respective FHFs, the entire incorporated area of the Township of Worcester was divided into zones, each having a specific flood potential or hazard. Each zone was assigned one of the following flood insurance zone designations:

Zone A:	Special Flood Hazard Areas inundated by the 100-year flood, determined by approximate methods; no base flood elevations shown or FHFs determined.
Zones A3 and A5:	Special Flood Hazard Areas inundated by the 100-year flood, determined by detailed methods; base flood elevations shown, and zones subdivided according to FHF.
Zone B:	Areas between the Special Flood Hazard Area and the limits of the 500-year flood, including areas of the 500-year flood plain that are protected from the 100-year flood by dike, levee, or other water control structure; also, areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; and areas subject to 100-year flooding from sources with drainage areas less than 1 square mile. Zone B is not subdivided.
Zone C:	Areas of minimal flooding.

Table 3, "Flood Insurance Zone Data," summarizes the flood elevation differences, FHFs, flood insurance zones, and base flood elevations for the flooding sources studied in detail in the Township of Worcester.

5.4 Flood Insurance Rate Map Description

The Flood Insurance Rate Map for the Township of Worcester is, for insurance purposes, the principal result of the Flood Insurance Study. This map (published separately) contains the official delineation of flood insurance zones and base flood elevation lines. Base flood elevation lines show the locations of the expected whole-foot water-surface elevations of the base (100-year) flood. This map is developed in accordance with the latest flood insurance map preparation guidelines published by the FIA.

6.0 OTHER STUDIES

Flood Insurance Studies for the contiguous communities of the Townships of East Norriton, Upper Gwynedd, and Whitpain have been prepared (References 9, 10, and 11). The results of this study are in exact agreement with the results of those studies. Flood Insurance Studies for the contiguous communities of the Townships of Skippack, Towamencin, and Lower Providence are currently being prepared (References 12, 13, and 14). The results of this study will be in exact agreement with the results of those studies. Also, the Flood Hazard Boundary Map for the Township of Worcester has been published (Reference 8).

A Special Flood Hazard Report for Zacharias and North Branch Zacharias Creeks was prepared by the COE (Reference 3). Minor differences exist in the water-surface elevations between the profiles of the Special Flood Hazard Report and the profiles in this study. The differences are due to minor adjustments to stream stationing based on more precise mapping and the addition of 2 new bridges downstream of the border of the Townships of Skippack and Worcester.

Hydrologic data contained in this report supersede data compiled and presented by the Delaware River Basin Commission, Hydrology Coordinating Committee, on September 21, 1978 (Reference 15). The revised data was gathered by the Coordinating Committee's representative from the COE.

7.0 LOCATION OF DATA

Survey, hydrologic, hydraulic, and other pertinent data used in this study can be obtained by contacting the office of the Insurance and Mitigation Division of the Federal Emergency Management Agency, Regional Director, Region III Office, Curtis Building, Sixth and Walnut Streets, Philadelphia, Pennsylvania 19106.

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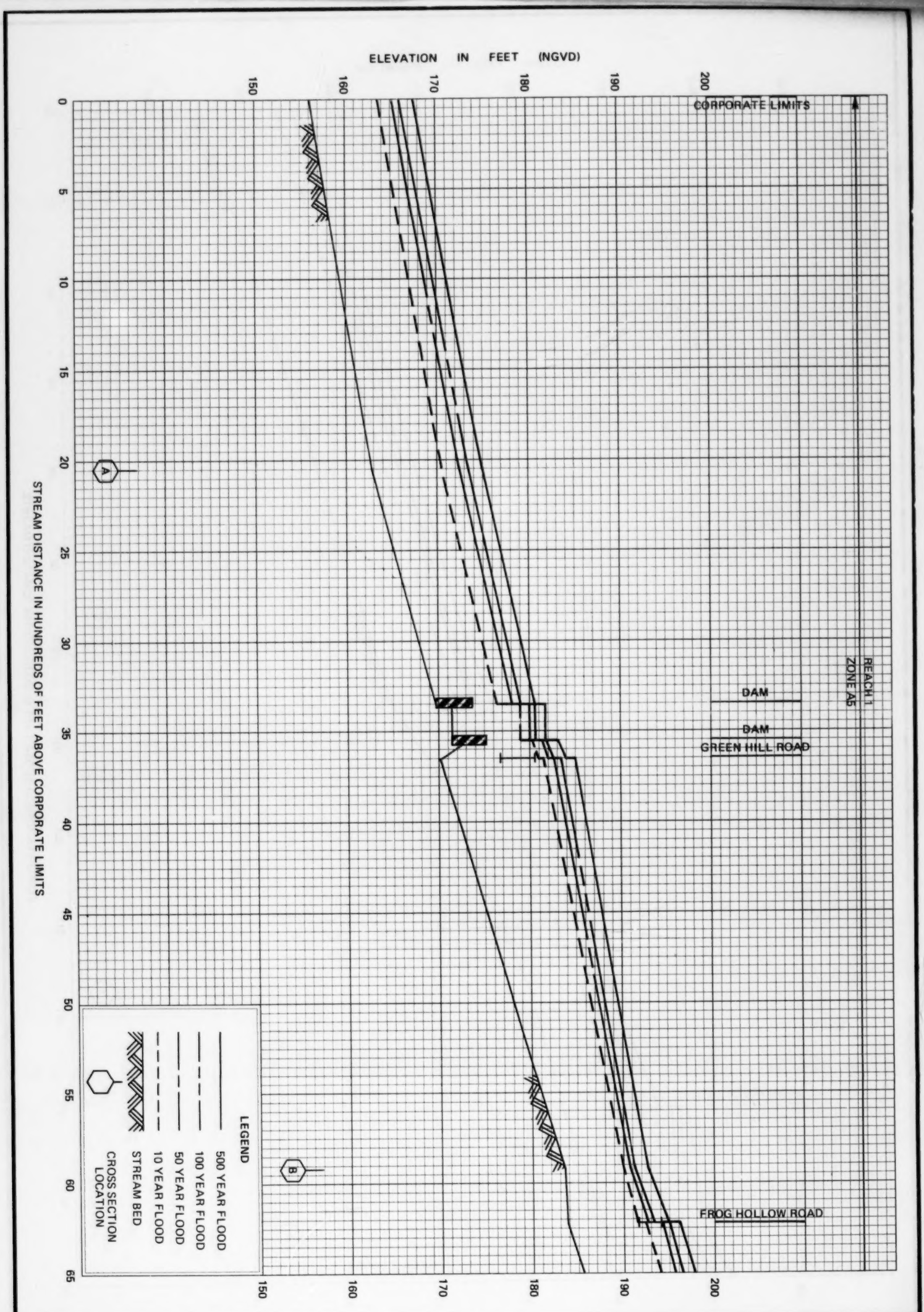


FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWNSHIP OF WORCESTER, PA
(MONTGOMERY CO.)

FLOOD PROFILES

ZACHARIAS CREEK

01P

REACH 1
ZONE A5

STATE ROUTE 363

STATE ROUTE 73

PRIVATE ROAD

ELEVATION IN FEET (NGVD)

250
240
230
220
210
200
190
180

65 70 75 80 85 90 95 100 105 110 115 120 125 130

STREAM DISTANCE IN HUNDREDS OF FEET ABOVE CORPORATE LIMITS

C D E F

LEGEND

- 500 YEAR FLOOD
- 100 YEAR FLOOD
- 50 YEAR FLOOD
- 10 YEAR FLOOD
- STREAM BED
- CROSS SECTION LOCATION

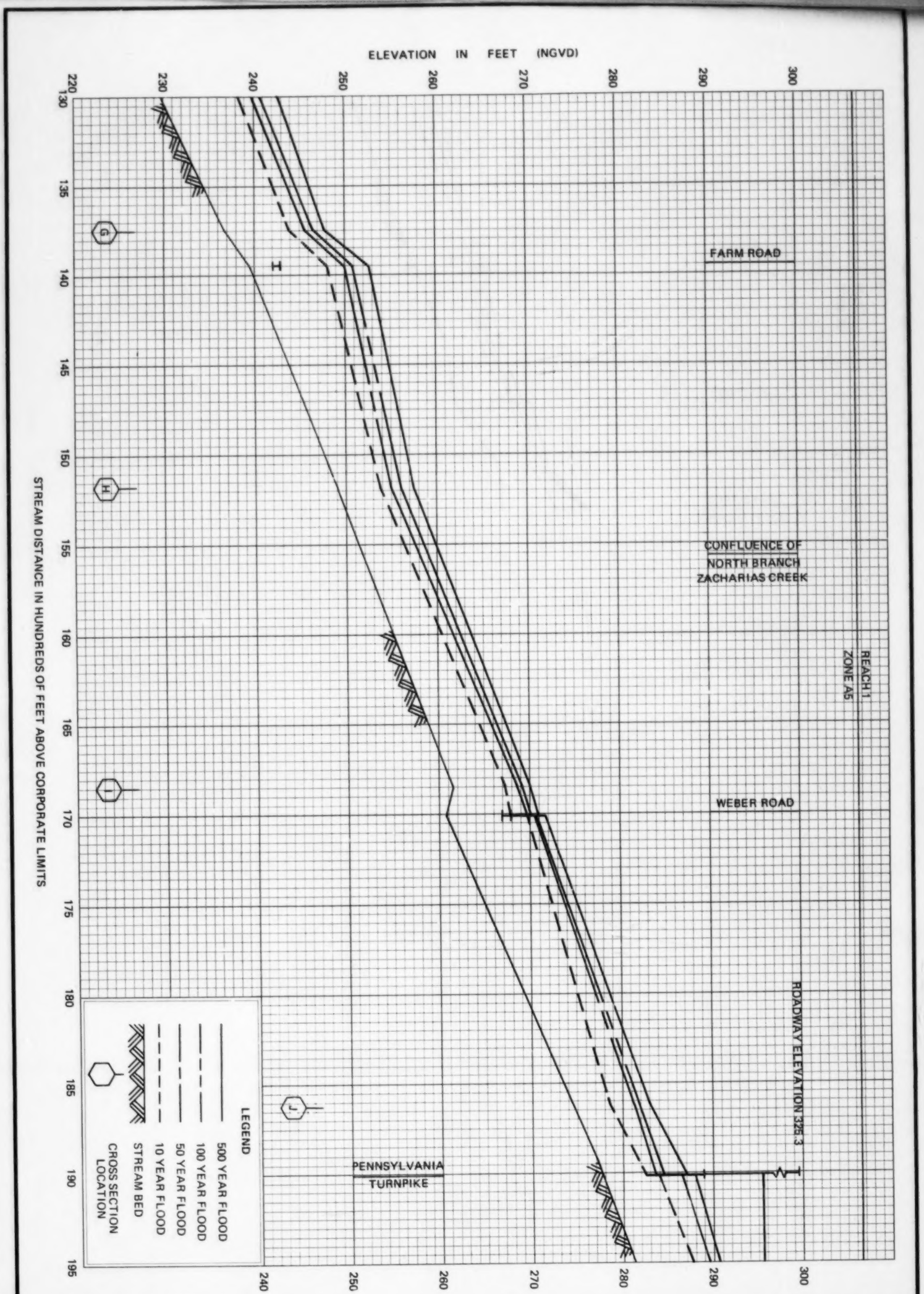
FLOOD PROFILES

ZACHARIAS CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWNSHIP OF WORCESTER, PA
(MONTGOMERY CO.)

02P



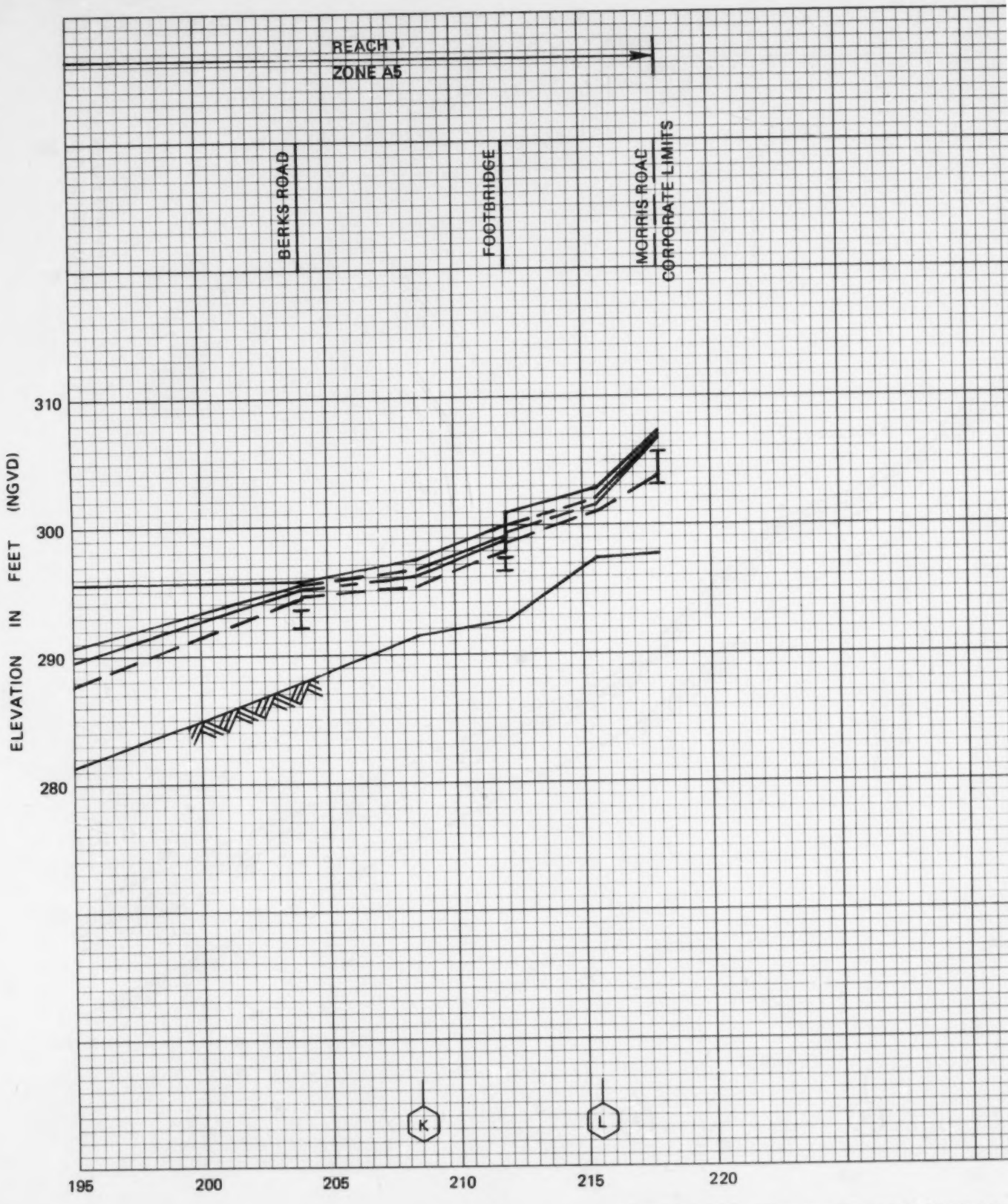
03P

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWNSHIP OF WORCESTER, PA
(MONTGOMERY CO.)

FLOOD PROFILES

ZACHARIAS CREEK


REACH 1
ZONE A5
BERKS ROAD
FOOTBRIDGE
MORRIS ROAD
CORPORATE LIMITS
ELEVATION IN FEET (NGVD)
310
300
290
280
K
L
195
200
205
210
215
220
STREAM DISTANCE IN HUNDREDS OF FEET ABO

LEGEND

500 YEAR FLOOD

100 YEAR FLOOD

50 YEAR FLOOD

10 YEAR FLOOD

STREAM BED

CROSS SECTION LOCATION

E CORPORATE LIMITS

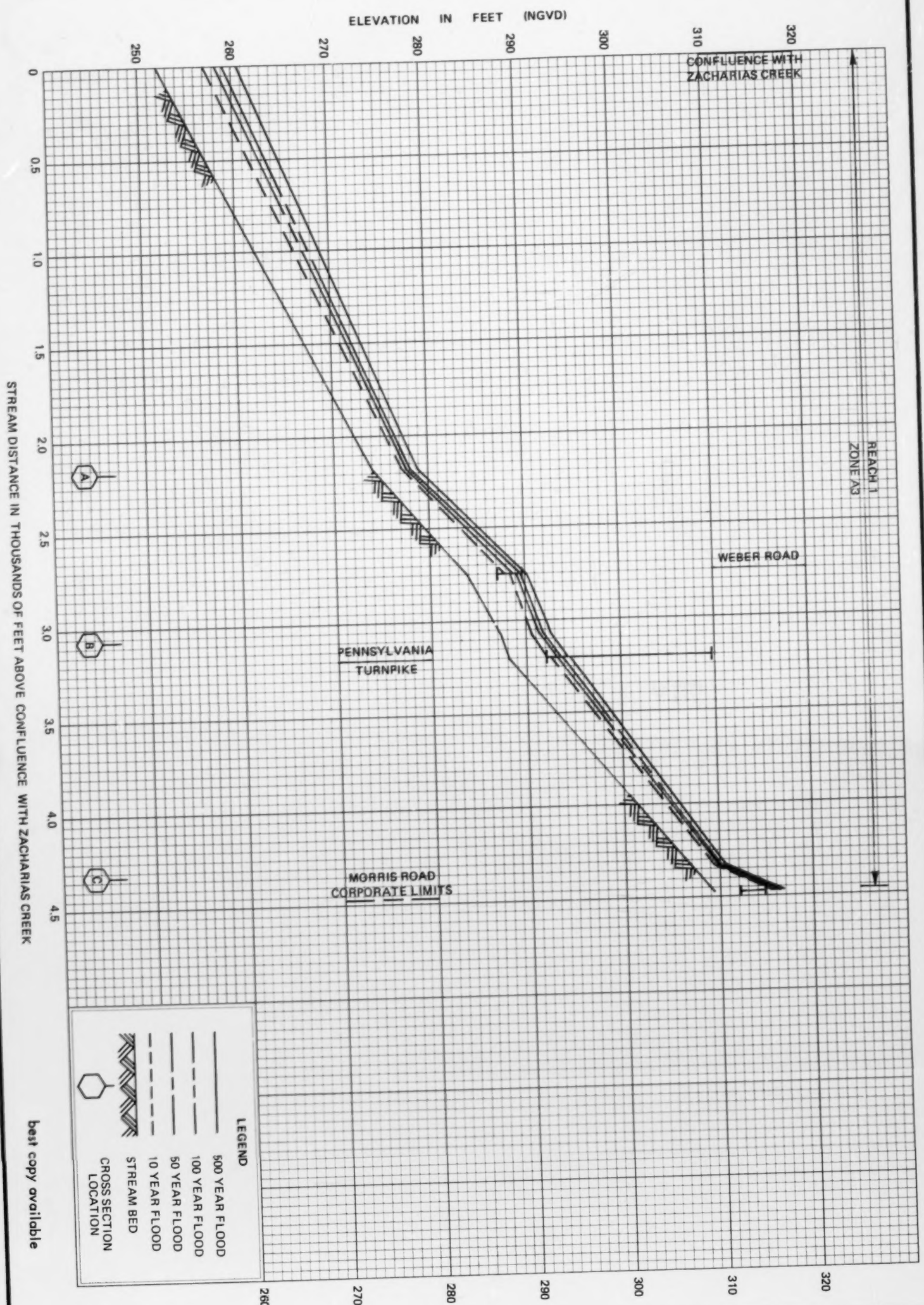
FLOOD PROFILES

ZACHARIAS CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWNSHIP OF WORCESTER, PA
(MONTGOMERY CO.)

04P



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FEDERAL EMERGENCY MANAGEMENT AGENCY
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FLOOD PROFILES

NORTH BRANCH ZACHARIAS CREEK